



US009629237B2

(12) **United States Patent**
Cho et al.

(10) **Patent No.:** **US 9,629,237 B2**
(45) **Date of Patent:** **Apr. 18, 2017**

(54) **ROLLABLE DISPLAY DEVICE**

B65H 2301/3611 (2013.01); *B65H 2301/415* (2013.01); *G09F 15/0062* (2013.01); *H04M 1/0268* (2013.01)

(71) Applicant: **LG Display Co., Ltd.**, Seoul (KR)

(72) Inventors: **Seok-Hyo Cho**, Goyang-si (KR); **Chul Park**, Goyang-si (KR)

(58) **Field of Classification Search**
CPC *G06F 1/1652*; *H04M 1/0268*; *G09F 9/301*; *Y10S 345/905*
See application file for complete search history.

(73) Assignee: **LG DISPLAY CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(56) **References Cited**

U.S. PATENT DOCUMENTS

(21) Appl. No.: **14/755,965**

5,467,210 A	11/1995	Kishigami
5,812,891 A	9/1998	Tokura
6,038,800 A	3/2000	Seidel
6,498,597 B1	12/2002	Sawano
6,762,929 B2	7/2004	Sawyer
6,771,232 B2	8/2004	Fujieda et al.
7,196,692 B2	3/2007	Mochizuki et al.
7,559,163 B2	7/2009	Ofuji et al.

(Continued)

(22) Filed: **Jun. 30, 2015**

(65) **Prior Publication Data**

US 2016/0029474 A1 Jan. 28, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/546,833, filed on Nov. 18, 2014, now Pat. No. 9,098,241.

FOREIGN PATENT DOCUMENTS

CN	103069473 A	4/2013
EP	2634765 A2	9/2013

(Continued)

(30) **Foreign Application Priority Data**

Jul. 22, 2014 (KR) 10-2014-0092343
Jul. 24, 2014 (KR) 10-2014-0093790

Primary Examiner — Nathan Milakovich
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(51) **Int. Cl.**

G09F 9/30	(2006.01)
H04M 1/02	(2006.01)
H05K 1/02	(2006.01)
G06F 1/16	(2006.01)
B65H 75/44	(2006.01)
B65H 75/28	(2006.01)
G09F 15/00	(2006.01)

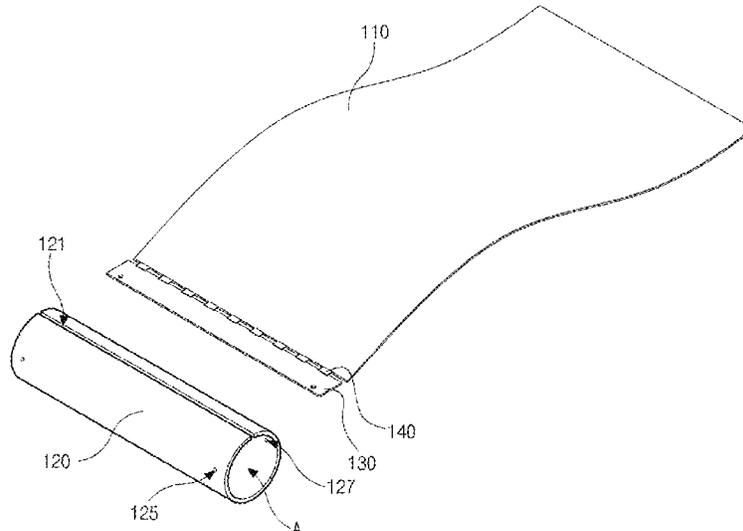
(57) **ABSTRACT**

A rollable display device includes a display panel for displaying an image, a printed circuit board connected to an edge of the display panel, and a roller which the display panel is rolled onto or unrolled from. The roller has a cylindrical shape having an inner space, and the printed circuit board is disposed in the inner space.

(52) **U.S. Cl.**

CPC *H05K 1/028* (2013.01); *B65H 75/28* (2013.01); *B65H 75/4402* (2013.01); *G06F 1/1652* (2013.01); *G09F 9/301* (2013.01);

19 Claims, 16 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

8,001,711 B2* 8/2011 LaFarre G02F 1/167
40/515
8,376,581 B2 2/2013 Auld et al.
8,477,250 B2* 7/2013 Schellingerhout G09F 9/301
345/55
8,477,464 B2 7/2013 Visser et al.
8,493,726 B2 7/2013 Visser et al.
8,508,920 B2 8/2013 Huitema et al.
8,516,728 B2 8/2013 Jung
8,665,236 B2 3/2014 Myers
8,711,566 B2 4/2014 O'Brien
2004/0264851 A1 12/2004 Amiri
2005/0040962 A1* 2/2005 Funkhouser G06F 1/1601
340/815.4
2005/0176470 A1 8/2005 Yamakawa
2006/0038745 A1 2/2006 Naksen et al.
2006/0207142 A1* 9/2006 Kochan G09F 11/29
40/604
2006/0288571 A1 12/2006 Seo et al.
2007/0241002 A1* 10/2007 Wu G06F 1/1601
206/150
2008/0049003 A1 2/2008 Hasegawa
2008/0247126 A1 10/2008 Otsuka et al.
2010/0038042 A1 2/2010 Criss
2010/0117975 A1 5/2010 Cho
2012/0050075 A1 3/2012 Salmon
2012/0314400 A1 12/2012 Bohn et al.

2013/0314762 A1 11/2013 Kwack et al.
2014/0247544 A1 9/2014 Ryu
2015/0009636 A1 1/2015 Jeong et al.
2015/0029229 A1 1/2015 Voutsas
2015/0227171 A1* 8/2015 Choi G06F 1/1652
361/749
2016/0139633 A1* 5/2016 Lee G06F 1/1652
345/33
2016/0187929 A1* 6/2016 Kim G06F 1/1652
345/184
2016/0231843 A1* 8/2016 Kim G06F 3/0412
2016/0239052 A1* 8/2016 Kim G06F 1/1652

FOREIGN PATENT DOCUMENTS

JP 2000-132122 A 5/2000
JP 2001-100661 A 4/2001
JP 2002-15858 A 1/2002
JP 2002-15859 A 1/2002
JP 2002-328625 A 11/2002
JP 2008-52040 A 3/2008
JP 2008-286901 A 11/2008
JP 2011-49411 A 3/2011
JP 2011-253029 A 12/2011
KR 10-2013-0028030 A 3/2013
KR 10-2013-0142447 A 12/2013
TW 200703166 A 1/2007
TW 201237720 A1 9/2012
WO WO 2014/080176 A1 5/2014

* cited by examiner

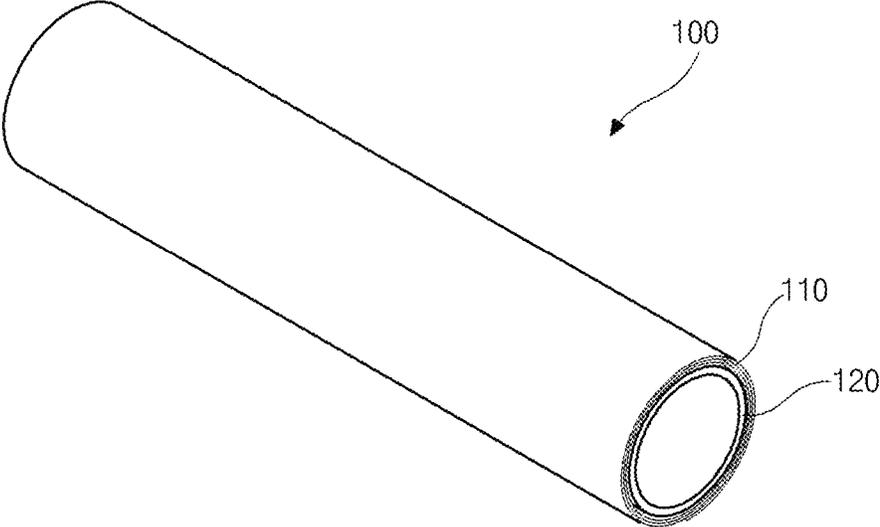


FIG. 1A

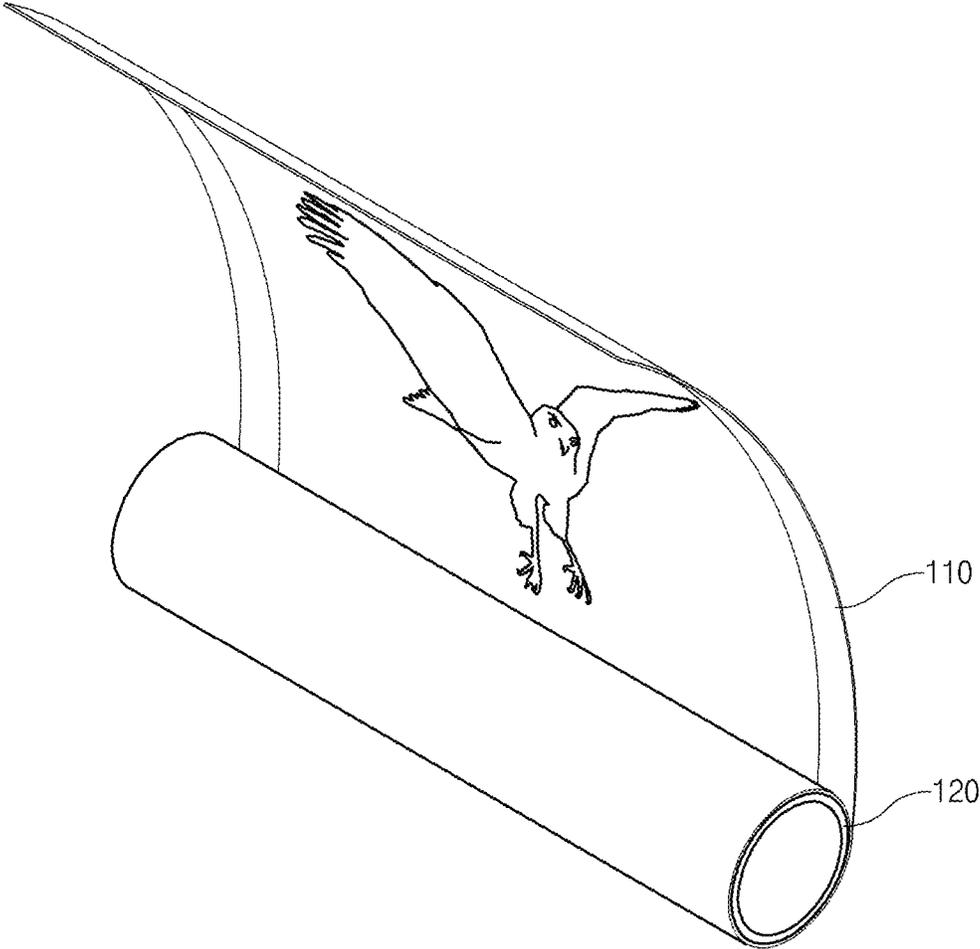


FIG. 1B

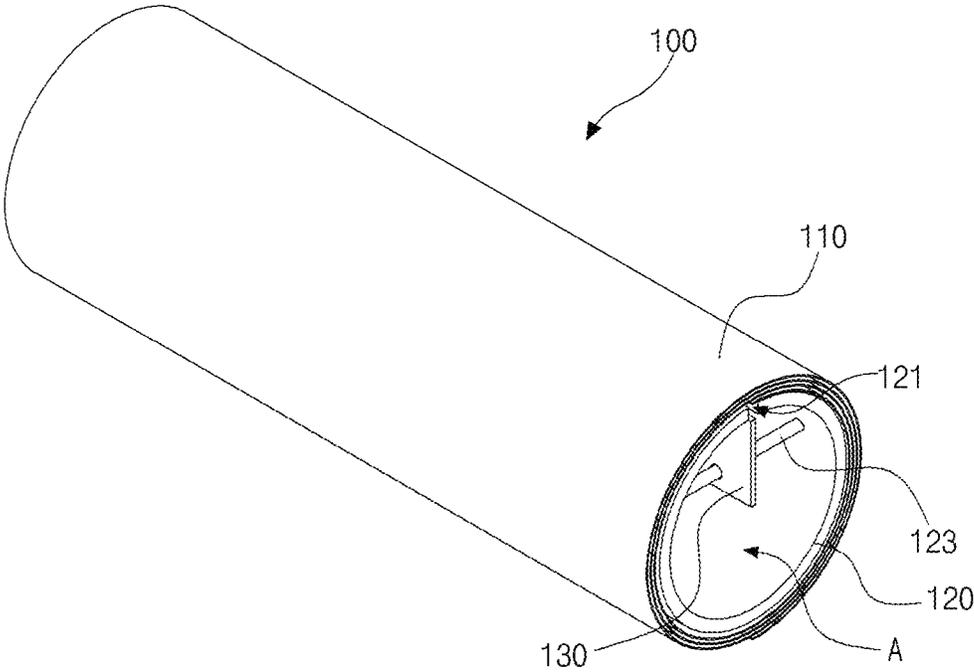


FIG. 2A

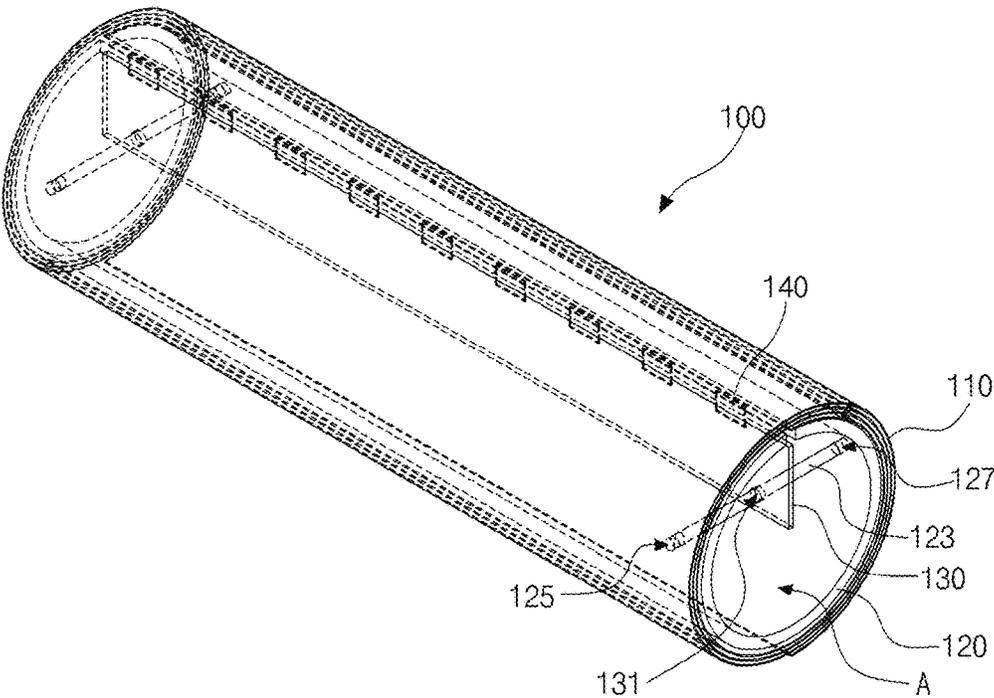


FIG. 2B

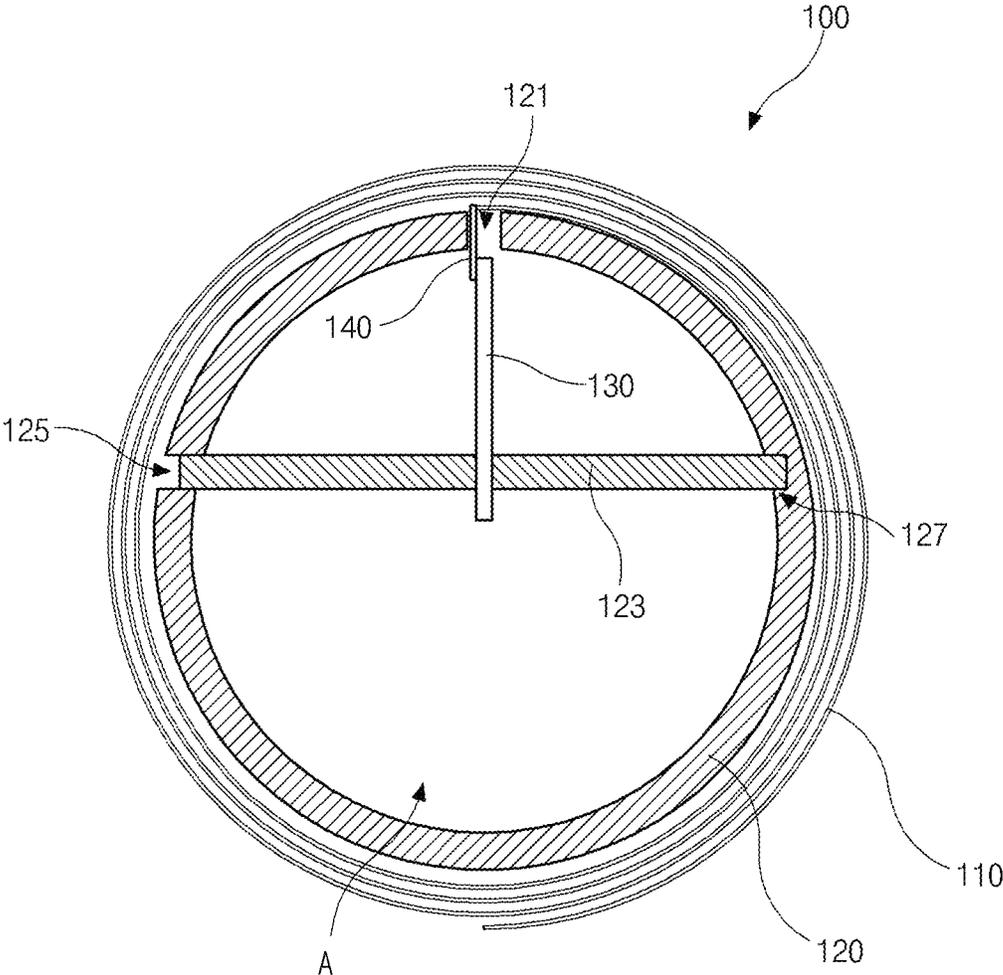


FIG. 2C

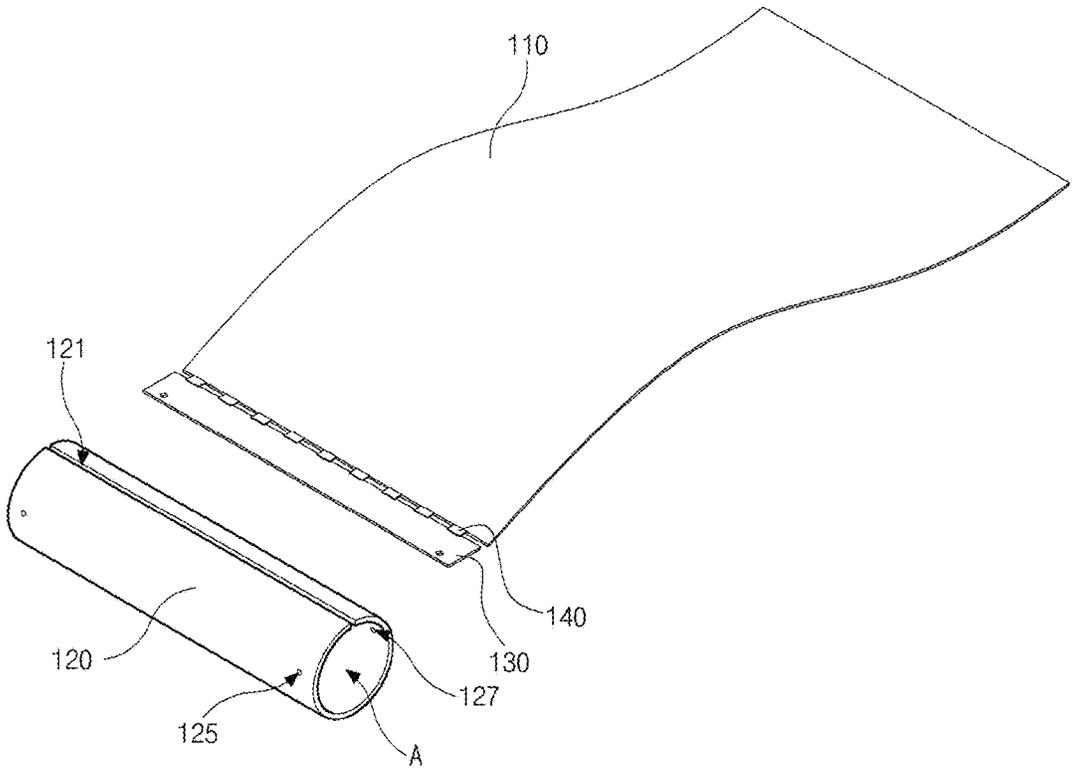


FIG. 3A

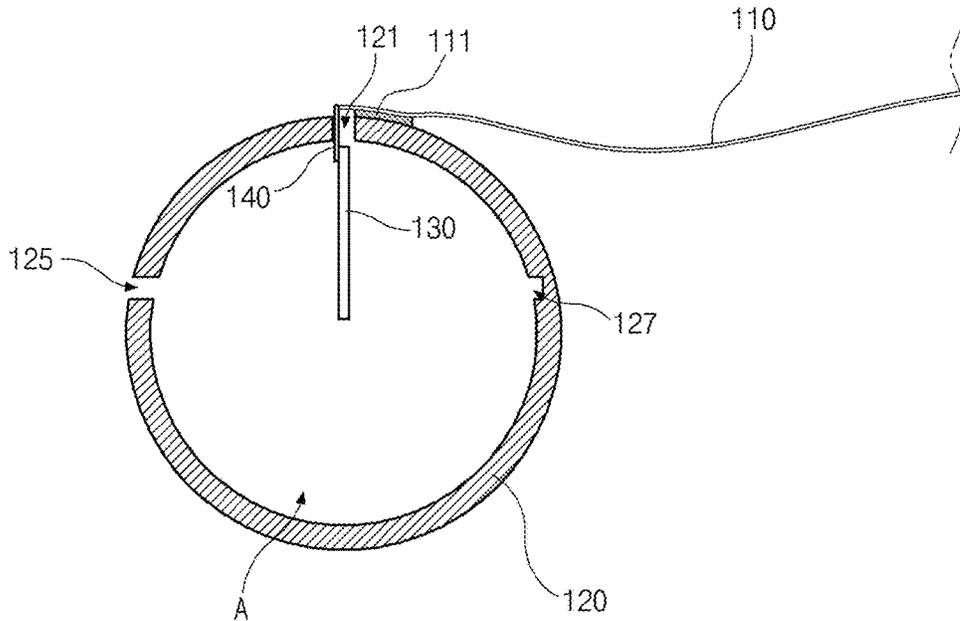


FIG. 3B

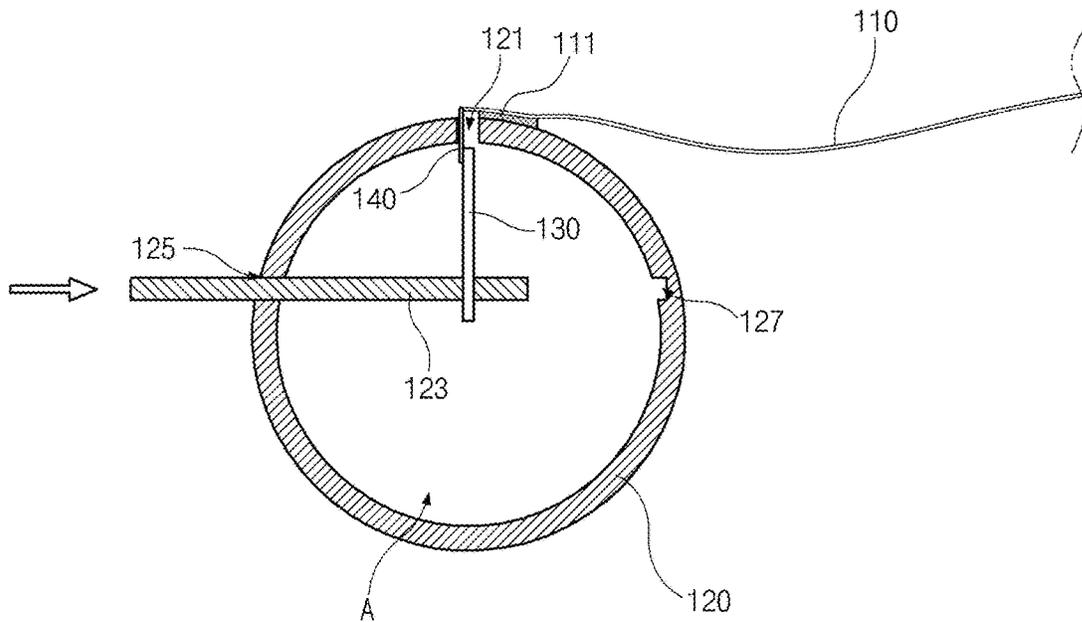


FIG. 3C

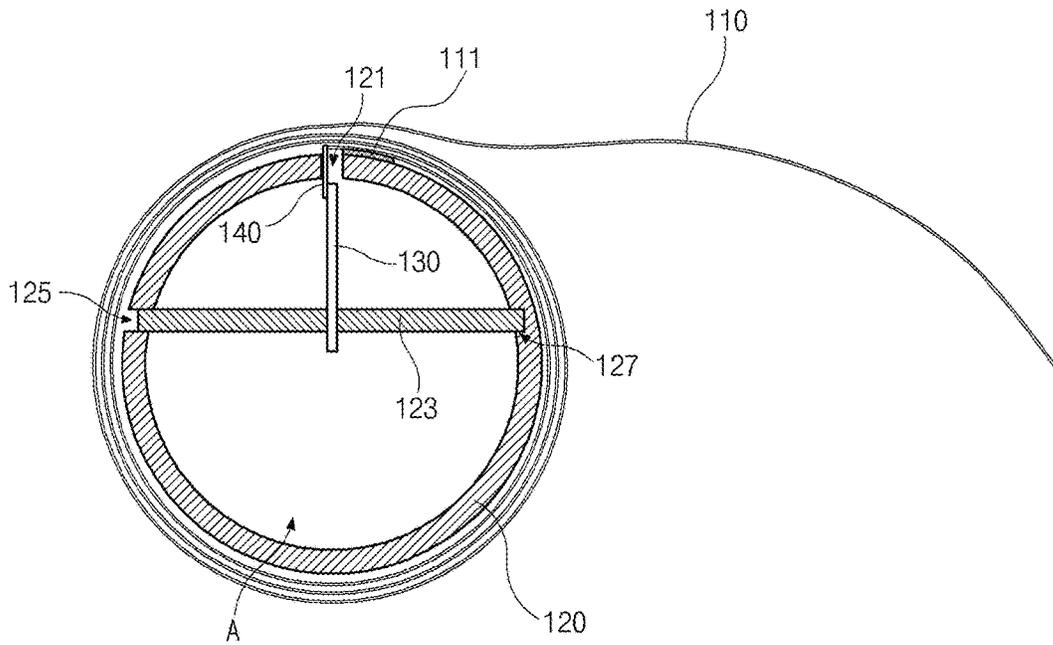


FIG. 3E

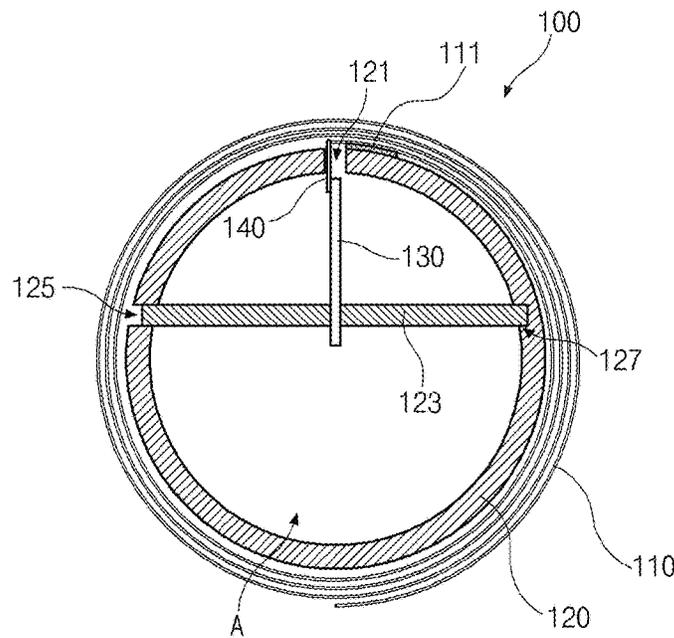


FIG. 3F



FIG. 4A

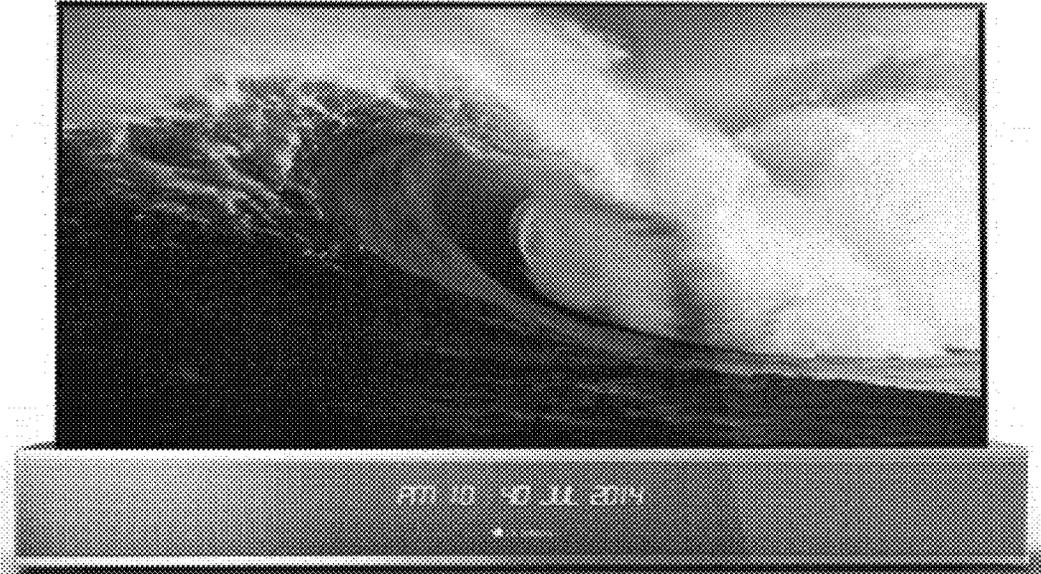


FIG. 4B

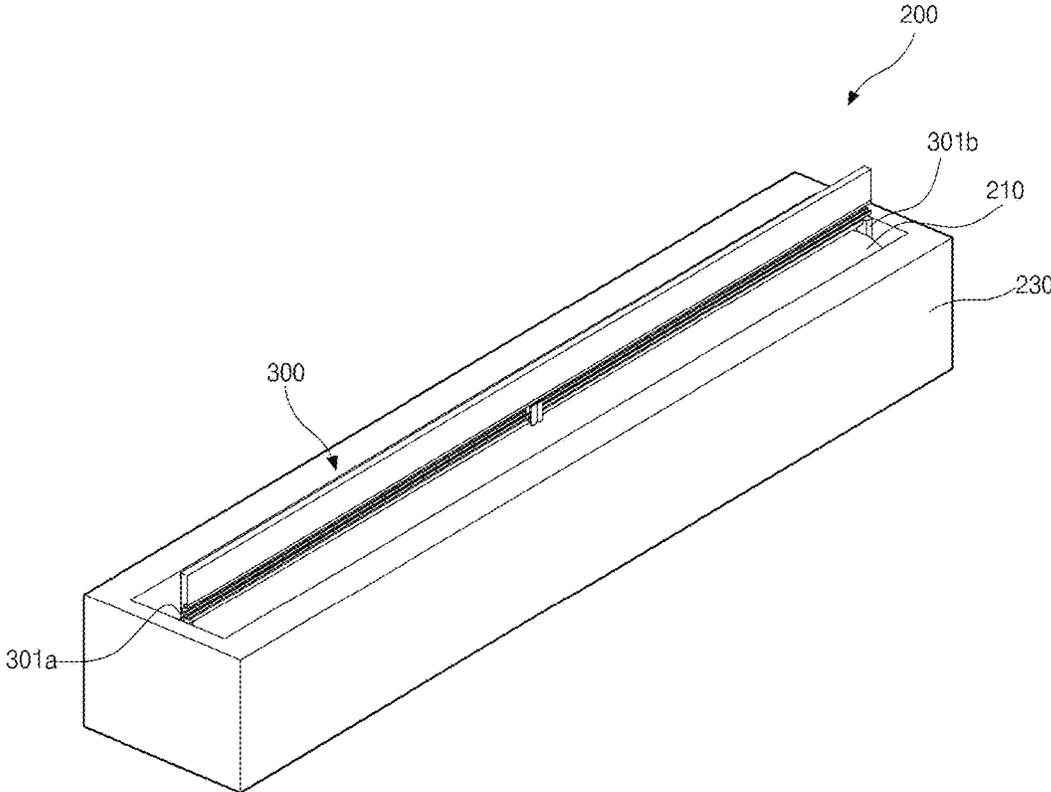


FIG. 5A

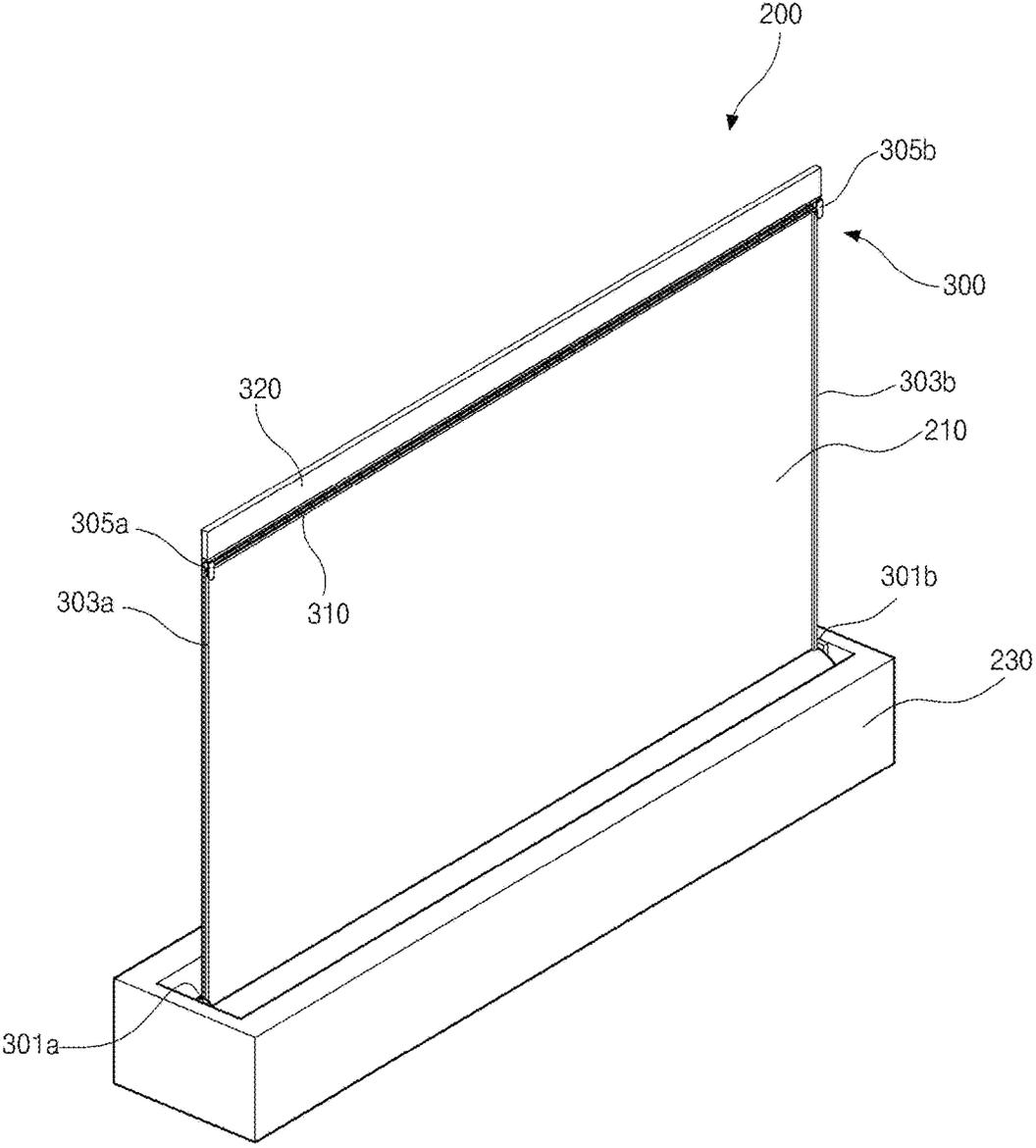


FIG. 5B

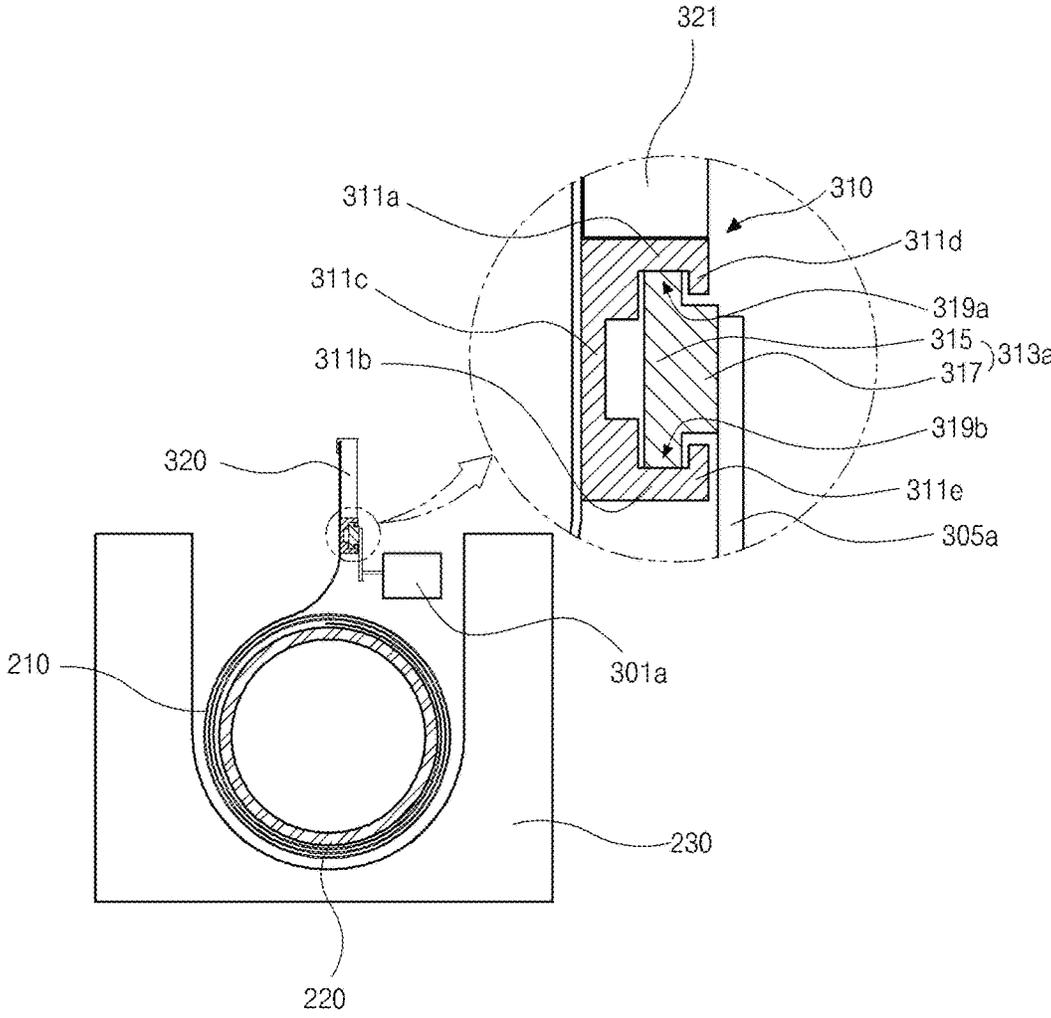


FIG. 6A

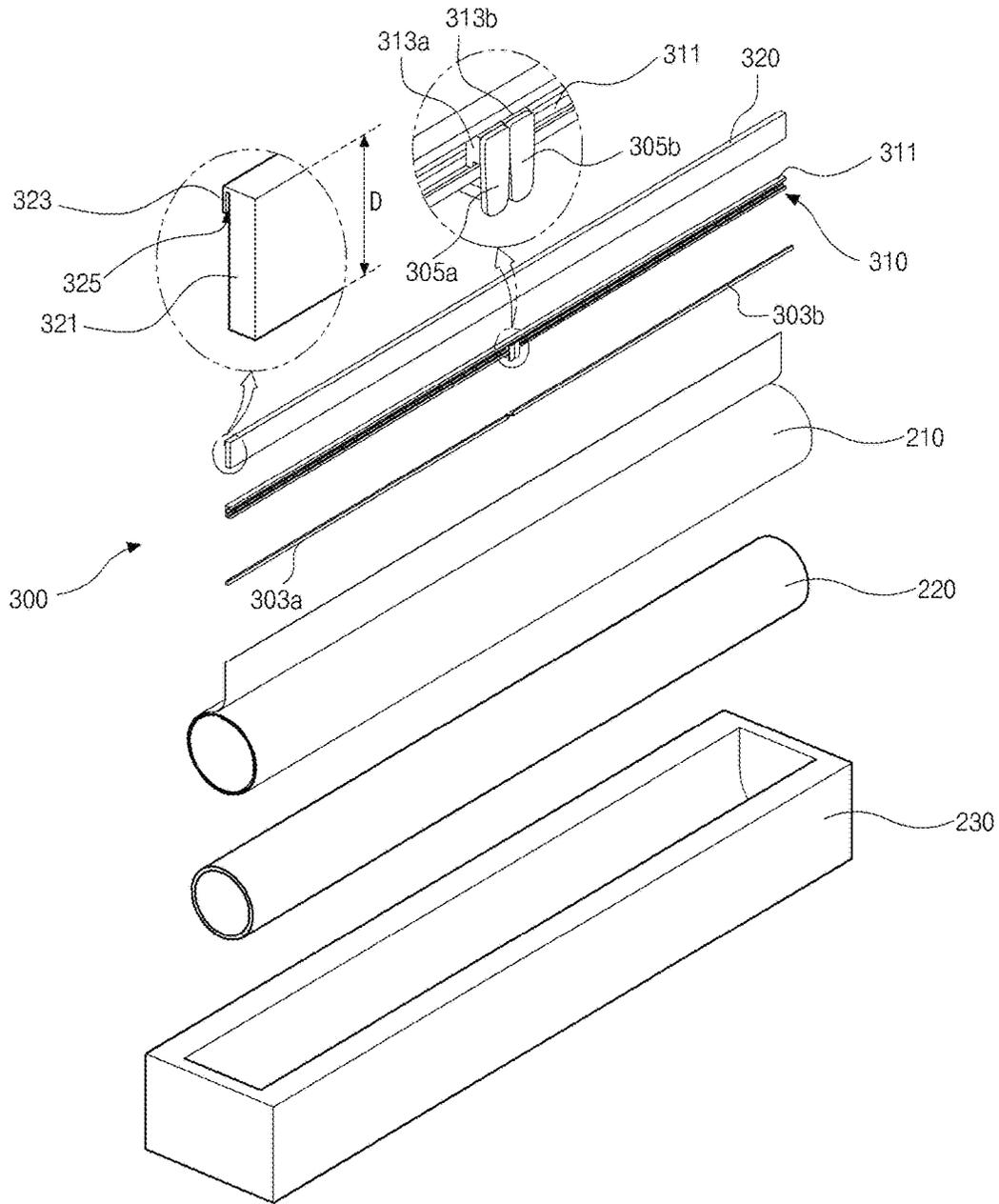


FIG. 6B

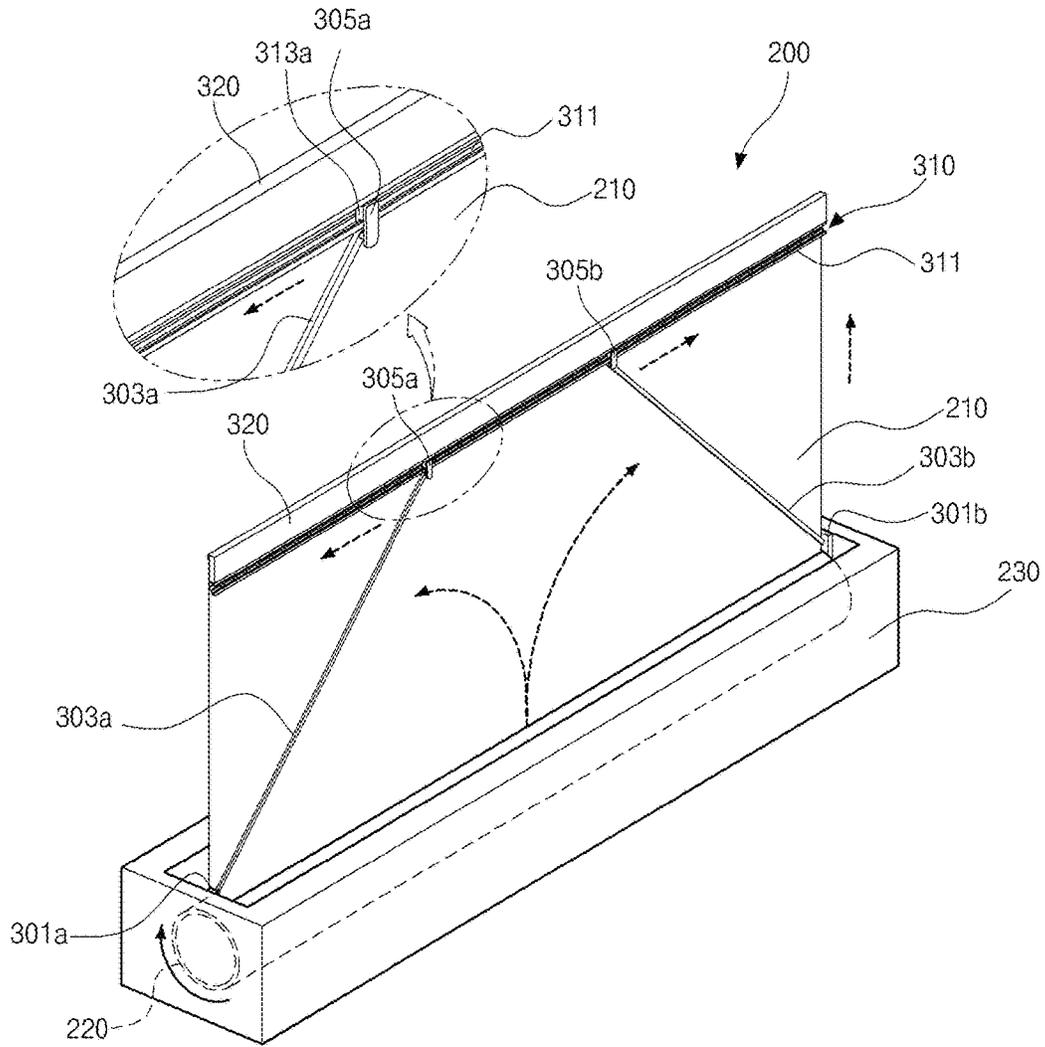


FIG. 6C

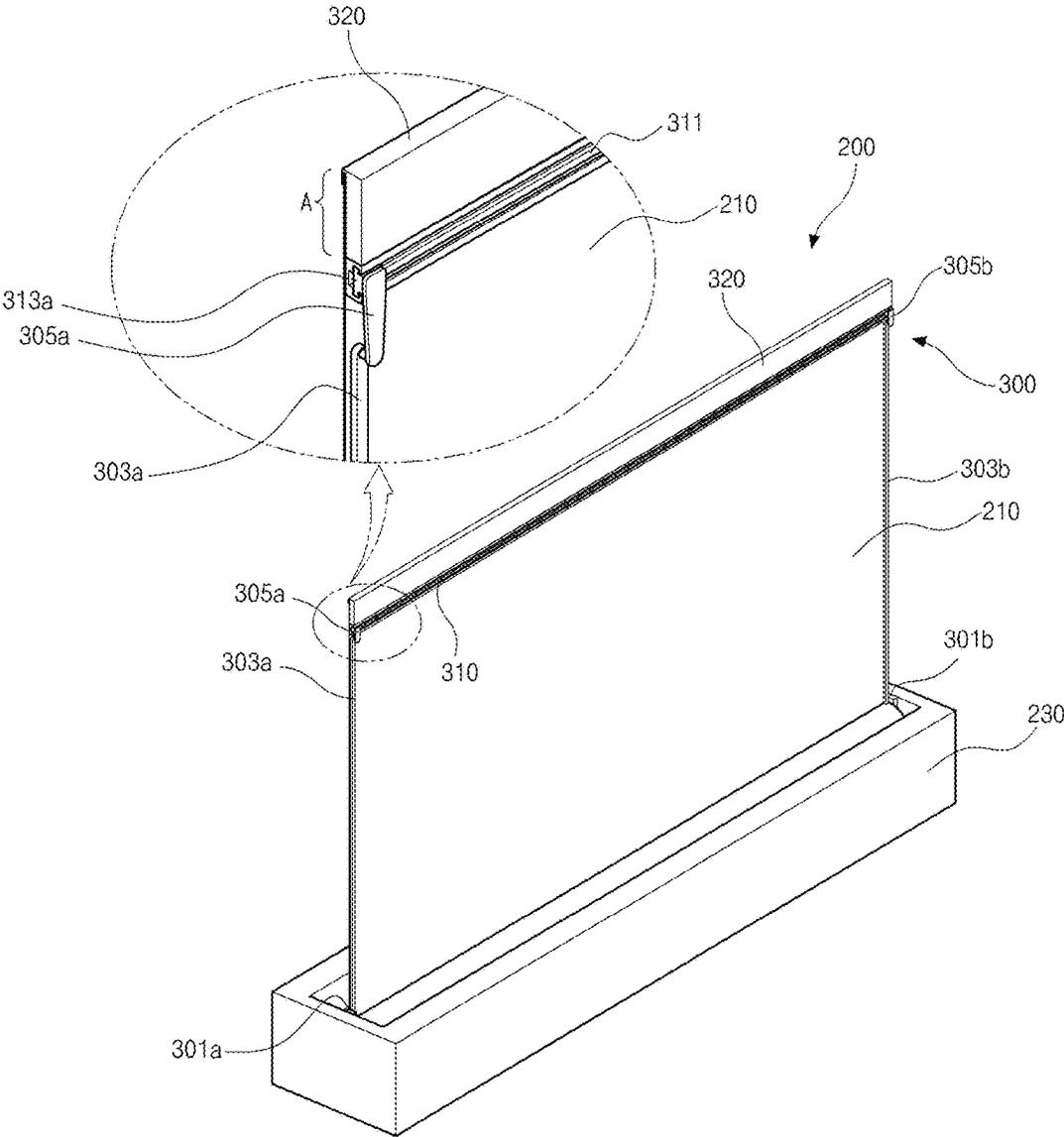


FIG. 6D

ROLLABLE DISPLAY DEVICE**CROSS-REFERENCE TO RELATED APPLICATIONS**

This Application is a Continuation of co-pending U.S. application Ser. No. 14/546,833 filed Nov. 18, 2014, which claims the benefit of priority of Korean Patent Application No. 10-2014-0092343 filed on Jul. 22, 2014, and No. 10-2014-0093790 filed on Jul. 24, 2014, which are hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND**Field of the Invention**

The present disclosure relates to a rollable display device. The present disclosure also relates to a rollable display device where a printed circuit board is stably fixed and a display panel is automatically rolled and unrolled.

Discussion of the Related Art

Recently, as the information society progresses, display devices processing and displaying a large amount of information have rapidly advanced and various flat panel displays (FPDs) have been developed. Specifically, the FPDs such as a liquid crystal display (LCD) device, a plasma display panel (PDP) device, an organic light emitting diode (OLED) display device and a field emission display (FED) device having superior performance with a thin profile, a light weight, and a low power consumption have substituted for a cathode ray tube (CRT).

Since the FPD uses a glass substrate resistant to the heat of a fabrication process, there exists a limit to the light weight, the thin profile and the flexibility of the FPD. As a result, a flexible display device which performs display function even when bent by using a flexible material such as plastic instead of the glass has been researched as a next generation FPD.

The flexible display devices may be classified into: an unbreakable display device which has a relatively high durability; a bendable display device which is capable of being bent; a rollable display device which is capable of being rolled; and a foldable display device which is capable of being folded. The flexible display device has advantages in a space application and interior decoration and design and has various applications. Specifically, a rollable display device has been researched for an ultra thin profile, a light weight and a portable size having a large display area.

SUMMARY OF THE INVENTION

In accordance with the present invention, as embodied and broadly described herein, the present invention provides a display device including a flexible display panel, a roller on which the flexible display panel is selectively wound and unwound, and a printed circuit board connected to the flexible display panel. The printed circuit board is located within the roller. A connector is provided interconnecting one end of the flexible display panel to the printed circuit board. The roller includes an aperture extending longitudinally along the roller. The connector is located within the aperture. An adhesive is provided for fixing the one end of the flexible display panel to the roller. A pin is provided to connect the printed circuit board to the roller. The pin has a first end located in a through hole provided in the roller and a second end located in a pin receiving portion provided in the roller, and extends through a pin hole provided in the

printed circuit board. The pin receiving portion may be a fixing groove provided in the roller. The roller may be formed as a circular cylinder or a hollow tube.

In another aspect, the present invention provides a display device including a case, a flexible display panel, a roller located within the case and on which the flexible display panel is selectively wound and unwound, and an elevating mechanism configured to extend the flexible display panel from the case. The elevating mechanism includes a guide rail attached to the flexible display panel, and a first link and a second link configured to elevate the guide rail. A first guide bracket is located at one end of the first link and movable along the guide rail, and a second guide bracket is located at one end of the second link and movable along the guide rail. The first guide bracket and the second guide bracket each include a guide portion located within the guide rail, and a rotational link portion extending from the guide portion. The rotational link portion of the first guide bracket is rotatably connected to the first link, and the rotational link portion of the second guide bracket is rotatably connected to the second link. A fixing bracket is provided to which the guide rail is attached. The fixing bracket includes a fixing portion having an inserting hole into which one end of the flexible display panel is inserted.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the embodiments as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments and together with the description serve to explain the principles of the disclosure. In the drawings:

FIGS. 1A and 1B are perspective views showing a rollable display device according to a first embodiment of the present disclosure.

FIG. 2A is a magnified view of FIG. 1A.

FIG. 2B is a projected view of FIG. 2A.

FIG. 2C is a cross-sectional view of FIG. 2A.

FIGS. 3A to 3F are views showing a method of fabricating a rollable display device according to a first embodiment of the present invention.

FIGS. 4A and 4B are views showing a rollable display device according to a second embodiment of the present disclosure.

FIGS. 5A and 5B are perspective views showing a rollable display device in an OFF state and an ON state, respectively, according to a second embodiment of the present disclosure.

FIG. 6A is a cross-sectional view showing a rollable display device in an OFF state according to a second embodiment of the present disclosure.

FIG. 6B is an exploded perspective view of FIG. 6A.

FIG. 6C is a perspective view showing a rollable display device changing from an OFF state to an ON state according to a second embodiment of the present disclosure.

FIG. 6D is a perspective view showing a rollable display device in an ON state according to a second embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings.

FIGS. 1A and 1B are perspective views showing a rollable display device according to a first embodiment of the present disclosure.

In FIGS. 1A and 1B, a rollable display device **100** includes a display panel **110** for displaying an image and a roller **120** where the display panel **110** is rolled.

The display panel **110** may include one of a liquid crystal display (LCD) device, a plasma display panel (PDP) device, an organic light emitting diode (OLED) display device and a field emission display (FED) device. For example, the display panel **110** may be the OLED display device as a flexible display device which keeps displaying an image even when bent like a paper.

Since a backlight unit for the LCD device of a non-emissive type is not required for the OLED display device of an emissive type, the OLED display device has a light weight and a thin profile. In addition, the OLED display device has advantages in a viewing angle, a contrast ratio and power consumption as compared with the LCD device. Further, the OLED display device can be driven with a low direct current (DC) voltage and has a rapid response speed. Moreover, since the inner elements of the OLED display device have a solid phase, the OLED display device has an excellent durability against an external impact and has a wide available temperature range. Specifically, since the OLED display device is fabricated through a simple process, the fabrication cost is reduced as compared with the LCD device.

The display panel **110** may include first and second substrates facing and spaced apart from each other and the first and second substrates may be attached using a protecting layer having an adhesive property.

Although not shown, the first and second substrates have a plurality of pixel regions in a display area. A driving thin film transistor may be formed in each pixel region on the first substrate. A first electrode connected to the driving thin film transistor is formed in each pixel region, and a light emitting layer emitting a colored light and a second electrode are sequentially formed on the first electrode. The light emitting layer emitting a light of red, green and blue colors may be formed by patterning an organic material. The first electrode, the light emitting layer and the second electrode may constitute a light emitting diode (LED). In addition, the first and second electrodes may function as an anode and a cathode, respectively.

The display panel **110** may have a non-display area surrounding the display area, and a plurality of lines and a plurality of driving chips for transmitting and generating driving signals and power signals are formed in the non-display area.

A printed circuit board (PCB) **130** (of FIG. 2A) electrically connected to the plurality of lines is attached to the non-display area of the display panel **110**. The PCB **130** may be connected to an edge of the display panel **110** through a connecting means **140** (of FIG. 2B) such as a flexible printed circuit (FPC) or a tape carrier package (TCP).

In an OFF state where the display panel **110** does not display an image, as shown in FIG. 1A, the display panel **110** is rolled onto the roller **120**. In an ON state where the display panel **110** displays an image, as shown in FIG. 1B, an end of the display panel **110** is unrolled from the roller **120** according to a user's demands.

The display panel **110** is rolled onto the roller **120** when the rollable display device **100** is not used and the display panel **110** is unrolled from the roller **120** when the rollable display device **100** is used. As a result, the rollable display device **100** has an advantage in a space application. In

addition, since the rollable display device **100** has an ultra thin profile and a light weight, the rollable display device **100** has advantages in interior decoration and design.

Since the PCB **130** connected to the edge of the display panel **110** is disposed in the roller **120**, an impact is not applied to the PCB **130** and a stress is not applied to the connecting means **140** between the PCB **130** and the display panel **110** when the display panel **110** is rolled onto the roller **120** and when the display panel **110** is unrolled from the roller **120**. As a result, breakdown of a driving circuit on the PCB **130** and disconnection between the PCB **130** and the display panel **110** are prevented, thereby preventing deterioration of signals and improving reliability of the rollable display device **100**.

Further, since the stress is not applied to the connecting means **140** between the PCB **130** and the display panel **110**, an additional fixing means for fixing the PCB **130** to the display panel **110** is omitted. As a result, a fabrication process is simplified and fabrication cost is reduced, thereby improving fabrication efficiency.

FIG. 2A is a magnified view of FIG. 1A, FIG. 2B is a projected view of FIG. 2A, and FIG. 2C is a cross-sectional view of FIG. 2A.

In FIGS. 2A to 2C, the roller **120** has a cylindrical shape having an inner space A, and the display panel **110** is rolled along an outer surface of the roller **120**. A guide hole **121** exposing the inner space A is formed along a length direction of the roller **120**. The edge of the display panel **110** where the PCB **130** is connected through the connecting means **140** is attached and fixed to the outer surface of the roller **120** adjacent to the guide hole **121** through an adhesive means **111** (of FIG. 3B) such as an adhesive resin or an adhesive double-sided tape, and the connecting means **140** and the PCB **130** is inserted into the guide hole **121** of the roller **120** to be disposed in the inner space A.

For example, an attaching area between the roller **120** and the display panel **110** may have a width greater than about 1 cm so that damage to the display panel **110** due to rotation of the roller **120** can be minimized when the display panel **110** is unrolled from the roller **120**.

The PCB **130** is stably fixed in the inner space A of the roller **120** by at least one pin **123** inserted through at least one pin hole **131** of the PCB **130**. For example, at least one pin hole **131** may be formed at both end portions of the PCB **130** along the length direction. Further, at least one through hole **125** where the at least one pin **123** may be inserted from the exterior may be formed in a portion of the roller **120**, and at least one fixing groove **127** where an end of the at least one pin **123** through the at least one through hole **125** and the at least one pin hole **131** is fixed may be formed on an inner surface of the opposite portion of the roller **120**.

As a result, when the PCB **130** inserted into the guide hole **121** is disposed in the inner space A of the roller **120**, the at least one pin **123** inserted into the at least one through hole **125** of the roller **120** passes through the at least one pin hole **131** of the PCB **130** to cross the inner space A and is fixed to the at least one fixing groove **127** of the roller **120**. Since a degree of freedom of the PCB **130** is restrained by the at least one pin hole **131** and the at least one hole **123**, the PCB **130** is stably fixed in the inner space A.

When the display panel **110** is rolled onto or unrolled from the roller **120**, an impact to the PCB **130** and a stress to the connecting means **140** between the PCB **130** and the display panel **110** are not applied. Accordingly, breakdown of a driving circuit on the PCB **130** and disconnection between the PCB **130** and the display panel **110** are prevented,

thereby preventing deterioration of signals and improving reliability of the rollable display device 100.

In addition, since the stress is not applied to the connecting means 140 between the PCB 130 and the display panel 110, an additional fixing means for fixing the PCB 130 to the display panel 110 is omitted, and a connection process such as a tape automated bonding (TAB) process is applicable to the rollable display device 100 without modification. As a result, a fabrication process is simplified and fabrication cost is reduced, thereby improving fabrication efficiency.

Further, since the at least one pin 123 crossing the inner space A of the roller 120 is fixed to the at least one fixing groove 127, the position of the at least one pin 123 is fixed in the inner space A of the roller 120, and the PCB 130 is more stably fixed in the inner space A of the roller 120.

FIGS. 3A to 3F are views showing a method of fabricating a rollable display device according to a first embodiment of the present invention.

In FIG. 3A, the rollable display device 100 includes the display panel 110 for displaying an image and the roller 120 where the display panel 110 is rolled. The roller 120 has a cylindrical shape having an inner space A, and the guide hole 121 exposing the inner space A is formed along a length direction of the roller 120. In addition, the at least one through hole 125 exposing the inner space A is formed in a portion of the roller 120 and the at least one fixing groove 127 is formed on the inner surface of the opposite portion of the roller 120.

The PCB 130 is connected to the edge of the flexible display panel 110 through the connecting means 140, and the at least one pin hole 131 (of FIG. 2B) is formed at both end portions of the PCB 130 along the length direction.

In FIG. 3B, after the PCB 130 and the connecting means 140 are inserted into the guide hole 121 of the roller to be disposed in the inner space A of the roller 120, the edge of the display panel 110 where the connecting means 140 is connected is fixed and attached to the outer surface of the roller 120 adjacent to the guide hole 121 through the adhesive means 111 such as an adhesive resin or an adhesive double-sided tape.

In FIG. 3C, the at least one pin 123 is inserted into the at least one through hole 125 from the exterior to cross the inner space A of the roller 120.

In FIG. 3D, the end of the at least one pin 123 through the at least one through hole 125 and the at least one pin hole 131 is fixed to the at least one fixing groove 127, so that the PCB 130 is stably fixed in the inner space A of the roller 120. As a result, an impact to the PCB 130 and a stress to the connecting means 140 between the PCB 130 and the display panel 110 are not applied even when the display panel 110 is rolled onto or unrolled from the roller 120. Accordingly, breakdown of a driving circuit on the PCB 130 and disconnection between the PCB 130 and the display panel 110 are prevented, thereby preventing deterioration of signals and improving reliability of the rollable display device 100.

In addition, since the stress is not applied to the connecting means 140 between the PCB 130 and the display panel 110, an additional fixing means for fixing the PCB 130 to the display panel 110 is omitted, and a connection process such as a tape automated bonding (TAB) process is applicable to the rollable display device 100 without modification. As a result, a fabrication process is simplified and fabrication cost is reduced, thereby improving fabrication efficiency.

In FIG. 3E, the display panel 110 is rolled onto the roller 120.

In FIG. 3F, the display panel 110 is completely rolled onto the roller 120 and the fabrication process of the rollable display device 100 is completed.

In the rollable display device 100 according to the first embodiment of the present disclosure, the display panel 110 is rolled onto the roller 120 when the rollable display device 100 is not used and the display panel 110 is unrolled from the roller 120 when the rollable display device 100 is used. As a result, the rollable display device 100 has an advantage in a space application. In addition, since the rollable display device 100 has an ultra thin profile and a light weight, the rollable display device 100 has advantages in interior decoration and design.

Specifically, since the PCB 130 is stably fixed in the inner space A of the roller 120, application of an impact to the PCB 130 and a stress to the connecting means 140 between the PCB 130 and the display panel 110 is prevented even when the display panel 110 is rolled onto or unrolled from the roller 120. Accordingly, breakdown of a driving circuit on the PCB 130 and disconnection between the PCB 130 and the display panel 110 are prevented, thereby preventing deterioration of signals and improving reliability of the rollable display device 100.

FIGS. 4A and 4B are views showing a rollable display device according to a second embodiment of the present disclosure.

In an OFF state where a display panel does not display an image, as shown in FIG. 4A, the display panel rolled onto a roller is disposed in a case. In an ON state where the display panel displays an image, as shown in FIG. 4B, a first side of the display panel is pulled upwardly from the case and the display panel is automatically spread out. Accordingly, the rollable display device has advantages in a space application. In addition, since the rollable display device has an ultra thin profile and a light weight, the rollable display device has advantages in interior decoration and design.

In the rollable display device, the display panel is spread out upwardly, and the case may be disposed on a bottom of a user's space. Since it is not necessary to install the rollable display device on a ceiling or a sidewall, the rollable display device may create a fine view to have an excellent effect in interior decoration and design. The installation of the rollable display device on the ceiling or the sidewall may be difficult and may require an expensive cost. Since the rollable display device is installed on the bottom, an additional installation is omitted and installation cost is reduced. Further, since the rollable display device has an ultra thin profile and a light weight, it is simple and easy to move and keep the rollable display device. Specifically, since the display panel is fully automatically rolled onto and unrolled from the roller, convenience of a user is improved.

FIGS. 5A and 5B are perspective views showing a rollable display device in an OFF state and an ON state, respectively, according to a second embodiment of the present disclosure.

In FIGS. 5A and 5B, a rollable display device 200 includes a display panel 210 displaying an image, a roller 220 (of FIG. 6A) where the display panel 210 is rolled, a driving unit 300 for rolling and unrolling the display panel 210 and a case 230 accommodating the roller 220. In an OFF state of the rollable display device 200, the display panel 210 is pulled downwardly into the case 230 and is rolled onto the roller 220. In an ON state of the rollable display device 200, the display panel 210 is unrolled from the roller 220 and is pulled upwardly from the case 230.

The display panel 210 may include one of a liquid crystal display (LCD) device, a plasma display panel (PDP) device, an organic light emitting diode (OLED) display device and

a field emission display (FED) device. For example, the display panel **210** may be the OLED display device as a flexible display device which keeps displaying an image even when bent like a paper.

Since a backlight unit for the LCD device of a non-emissive type is not required for the OLED display device of an emissive type, the OLED display device has a light weight and a thin profile. In addition, the OLED display device has advantages in a viewing angle, a contrast ratio and power consumption as compared with the LCD device. Further, the OLED display device can be driven with a low direct current (DC) voltage and has a rapid response speed. Moreover, since the inner elements of the OLED display device have a solid phase, the OLED display device has an excellent durability against an external impact and has a wide available temperature range. Specifically, since the OLED display device is fabricated through a simple process, the fabrication cost is reduced as compared with the LCD device.

The display panel **210** may include first and second substrates facing and spaced apart from each other and the first and second substrates may be attached using a protecting layer having an adhesive property.

Although not shown, the first and second substrates have a plurality of pixel regions in a display area. A driving thin film transistor may be formed in each pixel region on the first substrate. A first electrode connected to the driving thin film transistor is formed in each pixel region, and a light emitting layer emitting a colored light and a second electrode are sequentially formed on the first electrode. The light emitting layer emitting a light of red, green and blue colors may be formed by patterning an organic material. The first electrode, the light emitting layer and the second electrode may constitute a light emitting diode (LED). In addition, the first and second electrodes may function as an anode and a cathode, respectively.

The display panel **210** may have a non-display area surrounding the display area, and a plurality of lines and a plurality of driving chips for transmitting and generating driving signals and power signals are formed in the non-display area.

Although not shown, a printed circuit board (PCB) electrically connected to the plurality of lines is attached to the non-display area of the display panel **210**. The PCB may be connected to an edge of the display panel **210** through a connecting means such as a flexible printed circuit (FPC) or a tape carrier package (TCP).

In an OFF state where the display panel **210** does not display an image, as shown in FIG. 5A, the display panel **210** rolled onto the roller **220** is pulled downwardly to be disposed in the case **230**. In an ON state where the display panel **210** displays an image, as shown in FIG. 5B, the display panel **210** unrolled from the roller **220** is pulled upwardly to be spread outside the case **230**. The display panel **210** is fully automatically rolled onto and unrolled from the roller **220** by the driving unit **300** to have one of the OFF and ON states. In the rollable display device **200**, since the display panel **210** is easily rolled onto and unrolled from the roller **220** according to one of the OFF and ON states, convenience of a user is improved.

The driving unit **300** may include first and second motors **301a** and **301b**, first and second links **303a** and **303b**, a rail unit **310** and a fixing bracket **320**. The first and second motors **301a** and **301b** may generate a rotational force, and the first and second links **303a** and **303b** may move by the rotational force of the first and second motors **301a** and **301b**, respectively. For example, one end of each of the first

and second links **303a** and **303b** may be connected to each of the first and second motors **301a** and **301b**, and the other end of each of the first and second links **303a** may rotate with respect to the one end. The first and second links **303a** and **303b** may be connected to the rail unit **310** through first and second rotational links **305a** and **305b**, respectively. The fixing bracket **320** may be connected to the rail unit **310** to fix a first side of the display panel **210**.

The rail unit **310** may include a guide rail **311** (of FIG. 6A) having a length corresponding to a first side of the display panel **210**, and first and second guide brackets **313a** and **313b** (of FIG. 6B) moving along the guide rail **311**. The first and second guide brackets **313a** and **313b** are connected to the first and second links **303a** and **303b** through the first and second rotational links **305a** and **305b**, respectively. In addition, each of the first and second links **303a** and **303b** may have a length corresponding a half of the first side of the display panel **210**.

The one ends of the first and second links **303a** and **303b** may be disposed at end portions, respectively, of the case **230** along a length direction. The other ends of the first and second links **303a** and **303b** may be disposed to face each other or may circularly move by the rotational force of the first and second motors **301a** and **301b** to push the rail unit **310** and the fixing bracket **320** upwardly.

Since the rail unit **310** and the fixing bracket **320** are pushed upwardly, the first side of the display panel **210** fixed to the fixing bracket **320** is pulled upwardly and the display panel **210** is spread outwardly. When the display panel **210** is spread, the first and second links **303a** and **303b** support second and third sides, respectively, perpendicular to the first side of the display panel **210**.

As a result, in the rollable display device **200** according to the second embodiment of the present disclosure, the display panel **210** rolled onto the roller **220** is disposed in the case **230** in the OFF state, and the display panel **210** is pulled upwardly from the case **230** and displays an image in the ON state according to a user's demands. Specifically, since the display panel **210** is fully automatically rolled onto and unrolled from the roller **220**, convenience of a user is further improved.

FIG. 6A is a cross-sectional view showing a rollable display device in an OFF state according to a second embodiment of the present disclosure and FIG. 6B is an exploded perspective view of FIG. 6A. FIG. 6C is a perspective view showing a rollable display device changing from an OFF state to an ON state according to a second embodiment of the present disclosure and FIG. 6D is a perspective view showing a rollable display device in an ON state according to a second embodiment of the present disclosure.

In FIGS. 6A and 6B, the rollable display device **200** includes the display panel **210**, the roller **220**, the driving unit **300** and the case **230**. The display panel **210** is rolled onto the roller **220** and a first side of the display panel **210** is fixed to the fixing bracket **320** of the driving unit **300**.

The driving unit **300** includes the first and second motors **301a** and **301b**, the first and second links **303a** and **303b**, the rail unit **310** and the fixing bracket **320**. The first and second motors **301a** and **301b** generate a rotational force, and the first and second links **303a** and **303b** move by the rotational force of the first and second motors **301a** and **301b**, respectively. For example, first ends of the first and second links **303a** and **303b** may be connected to the first and second motors **301a** and **301b**, respectively, and the other ends of the first and second links **303a** may rotate with respect to the first ends. The first and second links **303a** and **303b** are

connected to the rail unit **310** through first and second rotational links **305a** and **305b**, respectively. The fixing bracket **320** is connected to the rail unit **310** to fix the first side of the display panel **210**.

The first side of the display panel **210** is fixed to the fixing bracket **320** and the fourth side opposite to the first side of the display panel **210** is fixed to the roller **220**. The fixing bracket **320** may include a supporting portion **321** supporting a rear surface of the first side of the display panel **210** and a fixing portion **323** protruding from one end of the supporting portion **321** toward a front of the display panel **210** where an image is displayed. The fixing portion **323** may include an inserting hole **325** into which the first side of the display panel **210** is inserted. The fixing bracket **320** may have a length corresponding to the first side of the display panel **210**.

The rail unit **310** is disposed under the fixing bracket **320** on the rear surface of the display panel **210**, and the guide rail **311** of the rail unit **310** is connected and fixed to the other end of the supporting portion **321** of the fixing bracket **320**. The guide rail **311** may have a length corresponding to the first side of the display panel **210**, and the first and second guide brackets **313a** and **313b** are connected to the guide rail **311** to move along the guide rail **311**.

The guide rail **311** having a "U" shape in cross-sectional view may include a first guide portion **311a** connected to the other end of the supporting portion **321** of the fixing bracket **320**, a second guide portion **311b** facing and parallel to the first guide portion **311a** and a connecting portion **311c** interconnecting the first and second guide portions **311a** and **311b** and perpendicular to the first and second guide portions **311a** and **311b**. In addition, third and fourth guide portions **311d** and **311e** are perpendicularly extend from the other ends of the first and second guide portions **311a** and **311b**, respectively, to constitute an opening of the guide rail **311**.

Each of the first and second guide brackets **313a** and **313b** may include a vertical guide portion **315** facing the connecting portion **311c** and a horizontal guide portion **317** protruding from the vertical guide portion **315** toward the opening of the guide rail **311**.

First and second guide holes **319a** and **319b** are formed in inner surfaces of the first and second guide portions **311a** and **311b**, respectively, and both ends of the vertical guide portion **315** of each of the first and second guide brackets **313a** and **313b** along a vertical direction are inserted into the first and second guide holes **319a** and **319b**, respectively.

The first and second guide brackets **313a** and **313b** move along the guide rail **311** with both ends of the vertical guide portion **315** inserted into the first and second guide holes **319a** and **319b** of the guide rail **311**. As a result, the first and second guide brackets **313a** and **313b** have a linear motion along a length direction of the guide rail **311**.

In the OFF state, as shown in FIG. 6B, the first and second guide brackets **313a** and **313b** are disposed at a central portion of the guide rail **311**.

First ends of the first and second rotational links **305a** and **305b** are fixed to the vertical guide portions **317** of the first and second guide brackets **313a** and **313b**, respectively, and the first and second rotational links **305a** and **305b** are rotatably connected to the first and second links **303a** and **303b**, respectively, under the rail unit **310**.

Each of the first and second links **303a** and **303b** may have a length corresponding to half of the first side of the display panel **210**. The first ends of the first and second links **303a** and **303b** may be connected to the first and second

motors **301a** and **301b**, respectively, and the other ends of the first and second links **303a** and **303b** may face each other.

First ends of the first and second rotational links **305a** and **305b** are fixed to the first and second guide brackets **313a** and **313b**, respectively, at the central portion of the guide rail **311**, and the other ends of the first and second rotational links **305a** and **305b** are rotatably connected to the other ends of the first and second links **303a** and **303b**, respectively. The other ends of the first and second rotational links **305a** and **305b** are rotatable with respect to the other ends of the first and second links **303a** and **303b**, respectively.

The first and second links **303a** and **303b** have a rotational motion. When the rotational force of the first and second motors **301a** and **301b** is transferred to the first and second links **303a** and **303b**, respectively, the first and second links **303a** and **303b** rotate with respect to the one ends thereof clockwise or counterclockwise. As a result, the other ends of the first and second links **303a** and **303b** move along curves (circular arc) corresponding to the rotational motion. In addition, the first and second rotational links **305a** and **305b** connected to the other ends of the first and second links **303a** and **303b** rotate according to the rotational motion of the first and second links **303a** and **303b**.

The rotational force of the first and second links **303a** and **303b** is transferred to the first and second guide brackets **313a** and **313b** through the first and second rotational links **305a** and **305b**, respectively. As a result, the first and second guide brackets **313a** and **313b** move from the central portion to opposite end portions of the guide rail **311** along the length direction of the guide rail **311**. The first and second guide brackets **313a** and **313b** have a linear motion opposite to each other due to the rotational force of the first and second links **303a** and **303b**.

Accordingly, the rail unit **310** and the fixing bracket **320** are pushed upwardly due to the rotational force of the first and second links **303a** and **303b** and the linear force of the first and second guide brackets **313a** and **313b**. As the rail unit **310** and the fixing bracket **320** are pushed upwardly, the display panel **210** fixed to the fixing bracket **320** is pushed upwardly to be unrolled from the roller **220**.

When the first and second links **303a** and **303b** are disposed perpendicular to the length direction of the display panel **210**, operation of the first and second motors **301a** and **301b** stops so that the rollable display device **200** can have the ON state as shown in FIG. 6D. In the ON state, the first and second links **303a** and **303b** may support the second and third sides, respectively, perpendicular to the first side of the display panel **210**. Accordingly, stiffness of the display panel **210** when fully spread out is improved.

Although not shown, a torque motor coupled with the first and second motors **301a** and **301b** may be formed in the roller **220**. When the first and second motors **301a** and **301b** operate, the torque motor may operate to correspond to the operation of the first and second motors **301a** and **301b**. As a result, while the display panel **210** is unrolled from the roller **220**, the roller **220** rotates due to the torque motor. Since the roller **220** rotates in addition to the rotational force of the first and second links **303a** and **303b** and the linear force of the first and second guide brackets **313a** and **313b** pushing the rail unit **310** and the fixing bracket **320** upwardly, the display panel **210** may be further easily pulled upwardly and may be further easily spread out.

In the rollable display device **200**, the display panel **210** may have an aspect ratio of 4:3 or 16:9, and each of the first and second links **303a** and **303b** may have a length corresponding to half of the first side of the display panel **210**. As

11

a result, when the display panel **210** of an aspect ratio of 16:9 has the first side of 16 and the second and third sides of 9, each of the first and second links **303a** and **303b** has a length of 8 ($=16/2$). Since the length of each of the first and second links **303a** and **303b** is shorter than each of the second and third sides of the display panel **210**, the first and second links **303a** and **303b** may not completely support the second and third sides of the display panel **210** and the display panel **210** may not be fully spread out. For the purpose of preventing the incomplete spread of the display panel **210**, in the rollable display device **200** according to the second embodiment of the present invention, the fixing bracket **320** fixing the first side of the display panel **210** supports a residual region A of the display panel **210** which is not supported by the first and second links **303a** and **303b**.

For example, the supporting portion **321** of the fixing bracket **320** may have a height D corresponding to the residual region A which is not supported by the first and second links **303a** and **303b**. In addition, the first side of the display panel **210** may be inserted into the inserting hole **325** formed in the fixing portion **323** protruding from one end of the supporting portion **321**. As a result, a length of each of the second and third sides of the display panel **210** may correspond to a sum of the height D of the supporting portion and a length of each of the first and second links **303a** and **303b**. Since the fixing bracket **320** may support and fix the residual region A, the display panel **210** may be fully spread out.

Further, although not shown, the display panel **210** and the roller **220** of the second embodiment may have the same structure as the display panel **110** and the roller **120** of the first embodiment. For example, a printed circuit board (PCB) may be connected to a fourth side opposite to the first side of the display panel **210** through a connecting means. In addition, the roller **220** may have a guide hole, a through hole and a fixing groove, and the PCB may have a pin hole. The PCB and the connecting means may be inserted into the guide hole and a pin may be inserted into the through hole and the pin hole to be fixed to the fixing groove, thereby stably fixing the PCB in the roller **220**.

Consequently, in the rollable display device **200** according to the second embodiment of the present invention, the display panel **210** is rolled onto the roller **220** and is disposed in the case **230** in the OFF state where the display panel **210** does not display an image. In addition, the display panel **210** is pulled upwardly from the case **230** and is automatically spread out in the ON state where the display panel **210** displays an image. Accordingly, the rollable display device **200** has advantages in a space application. Further, since the rollable display device **200** has an ultra thin profile and a light weight, the rollable display device **200** has advantages in interior decoration and design.

Moreover, the display panel **210** is spread out upwardly, and the case **230** may be disposed on a bottom of a user's space. Since it is not necessary to install the rollable display device **200** on a ceiling or a sidewall, the rollable display device **200** may create a fine view to have an excellent effect in interior decoration and design. The installation of the rollable display device **200** on the ceiling or the sidewall may be difficult and may require an expensive cost. Since the rollable display device **200** is installed on the bottom, an additional installation is omitted and installation cost is reduced.

Furthermore, since the rollable display device **200** has an ultra thin profile and a light weight, it is simple and easy to move and keep the rollable display device **200**. Specifically,

12

since the display panel **210** is fully automatically rolled onto and unrolled from the roller **220**, convenience of a user is improved.

In a method of providing a display, the flexible display panel **110**, **210** is provided and configured to produce an image. A portion of the flexible display panel **110**, **210** is elevated to unfurl the flexible display panel **110**, **210**. One manner of unfurling the flexible display panel **110**, **210** is by unrolling the flexible display panel **110**, **210** during the elevating of the portion of the flexible display panel **110**, **210**. The flexible display panel **110**, **210** may be unrolled from a housing/case **230** by elevating one end of the flexible display panel **110**, **210** by upwardly pushing the one end of the flexible display panel **110**, **210**. Conversely, the flexible display panel **110**, **210** may be rolled up into the case **230** by lowering the one end of the flexible display panel **110**, **210**. The flexible display panel **110**, **210** may be unrolled from or rolled up onto a roller **120**, **220** provided within the case **230**.

As discussed previously, an elevating mechanism is providing for elevating the portion of the flexible display panel **110**, **210** by extending the flexible display panel **110**, **210** from the case **230**. The elevating mechanism includes a guide rail **311** attached to the portion of the flexible display panel **110**, **210**, and links **303a**, **303b** configured to elevate the guide rail **311**. In addition, as discussed previously, a printed circuit board **130** is connected to the flexible display panel **110**, **210** and located within the roller **120**, **220**, and is configured to transmit a signal from the printed circuit board **130** to the flexible display panel **110**, **210** to produce an image by the flexible display panel **110**, **210**.

It will be apparent to those skilled in the art that various modifications and variations can be made in a rollable display device of the present disclosure without departing from the spirit or scope of the disclosure. Thus, it is intended that the present disclosure covers the modifications and variations of these embodiments provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A display device comprising:

- a flexible display panel;
- a roller on which the flexible display panel is selectively wound and unwound, the roller having:
 - a curved surface having a first end and a second end; and
 - a slit extending longitudinally along the curved surface of the roller, the slit being located between a first sidewall portion of the roller and a second sidewall portion of the roller, the second sidewall portion facing the first sidewall portion to define the slit therebetween, at least a portion of the roller extending continuously along the circumference of the roller from the first sidewall portion to the second sidewall portion with the slit therebetween, wherein the slit is the only slit extending longitudinally along the curved surface of the roller from the first end of the curved surface to the second end of the curved surface; and
 - a printed circuit board connected to the flexible display panel, the printed circuit board being located within the roller.

2. The display device of claim 1, wherein the roller is configured to rotate about an axis of rotation, and the slit extends parallel to the axis of rotation.

3. The display device of claim 1, further comprising a connector interconnecting one end of the flexible display panel to the printed circuit board.

13

- 4. The display device of claim 3, wherein the connector is located within the slit.
- 5. The display device of claim 1, further comprising a pin connecting the printed circuit board to the roller.
- 6. A display device comprising:
 - a flexible display panel;
 - a roller on which the flexible display panel is selectively wound and unwound, the roller having:
 - a curved surface having a first end and a second end; and
 - a slit extending longitudinally along the curved surface of the roller, the slit being located between a first sidewall portion of the roller and a second sidewall portion of the roller, the second sidewall portion facing the first sidewall portion to define the slit therebetween, at least a portion of the roller extending uninterrupted from the first sidewall portion to the second sidewall portion;
 - a printed circuit board connected to the flexible display panel, the printed circuit board being located within the roller; and
 - a pin connecting the printed circuit board to the roller, wherein the pin has a first end located in a through hole provided in the roller, wherein the pin extends through a pin hole provided in the printed circuit board, and wherein the pin has a second end located in a pin receiving portion provided in the roller.
- 7. The display device of claim 6, wherein the pin receiving portion is a fixing groove provided in the roller.
- 8. The display device of claim 1, wherein the roller is a circular cylinder.
- 9. The display device of claim 1, wherein the curved surface of the roller forms a tube having a hollow interior, and wherein the slit extends through the curved surface of the roller to the hollow interior.
- 10. The display device of claim 9, wherein the roller is configured to rotate about an axis of rotation, and the slit extends parallel to the axis of rotation.
- 11. The display device of claim 9, further comprising:
 - a case, the roller being located within the case; and
 - an elevating mechanism configured to extend the flexible display panel from the case, including:
 - a guide rail attached to the flexible display panel; and
 - a first link configured to elevate the guide rail.
- 12. The display device of claim 11, further comprising a first guide bracket located at one end of the first link and movable along the guide rail.
- 13. The display device of claim 11, further comprising a second link configured to elevate the guide rail.

14

- 14. The display device of claim 13, further comprising:
 - a first guide bracket located at one end of the first link and movable along the guide rail; and
 - a second guide bracket located at one end of the second link and movable along the guide rail.
- 15. The display device of claim 14, wherein the first guide bracket and the second guide bracket each include:
 - a guide portion located within the guide rail; and
 - a rotational link portion extending from the guide portion, wherein the rotational link portion of the first guide bracket is rotatably connected to the first link, and the rotational link portion of the second guide bracket is rotatably connected to the second link.
- 16. The display device of claim 15, further comprising a fixing bracket to which the guide rail is attached, wherein the fixing bracket includes a fixing portion having an inserting hole into which one end of the flexible display panel is inserted.
- 17. The display device of claim 11, further comprising a fixing bracket provided at one end of the flexible display panel.
- 18. The display device of claim 17, wherein the guide rail is attached to the fixing bracket.
- 19. A display device comprising:
 - a flexible display panel;
 - a roller on which the flexible display panel is selectively wound and unwound, the roller having:
 - a curved surface having a first end and a second end; and
 - a slit extending longitudinally along the curved surface of the roller, the slit being located between a first sidewall portion of the roller and a second sidewall portion of the roller, the second sidewall portion facing the first sidewall portion to define the slit therebetween, at least a portion of the roller extending uninterrupted from the first sidewall portion to the second sidewall portion, wherein the curved surface of the roller forms a tube having a hollow interior, and wherein the slit extends through the curved surface of the roller to the hollow interior.
 - a printed circuit board connected to the flexible display panel, the printed circuit board being located within the roller;
 - a case, the roller being located within the case;
 - an elevating mechanism configured to extend the flexible display panel from the case, including:
 - a guide rail attached to the flexible display panel; and
 - a first link configured to elevate the guide rail; and
 - a fixing bracket provided at one end of the flexible display panel,
 - wherein the fixing bracket includes a fixing portion having an inserting hole into which the one end of the flexible display panel is inserted.

* * * * *